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## (54) IMPROVEMENTS IN OR RELATING TO AXIAL PISTON HYDRAULIC MACHINES

(71) We, REGIE NATIONALE DES  
USINES RENAULT, a French Body Corporate  
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BILLANCOURT, Hauts de Seine, FRANCE,  
do hereby declare the invention for which we  
pray that a patent may be granted to us and  
the method by which it is to be performed to  
be particularly described in and by the  
following statement:-

- 10 This invention relates in general to axial-  
piston hydraulic machines of which the  
multifarious applications as hydraulic pumps  
or motors are well known. It relates more  
particularly to the development of a hydraulic  
15 machine of the axial piston type wherein the  
pistons are slidably mounted in parallel  
cylinders consisting of bores formed in a  
barrel-like member, said bores opening along  
a circular path concentric with the axis of  
20 rotation of said barrel and registering with a  
distribution plate in which high- and low-  
pressure ports are formed for the hydraulic  
fluid, said barrel being rotatably mounted in  
relation to said distribution plate of which  
25 the face opposite the barrel-engaging sliding  
face has an arcuate configuration and co-acts  
with a corresponding arcuate face of the  
machine case, said distribution plate being  
movable while in engagement with said  
30 corresponding arcuate face for varying the  
barrel inclination in said case, the arcuate face  
of said case comprising low- and high-  
pressure fluid passage orifices connected to  
elongated orifices formed in said distribution  
35 plate which communicate through internal  
passages with the aforesaid ports, said  
elongated orifices being adapted, in all  
angular positions of said plate, to cover the  
high- and low-pressure orifices of said case.
- 40 In a known practical embodiment of

machines of this character the cross-section  
or surface area of at least one high-pressure  
elongated orifice of said distribution plate is  
reduced in comparison with that of the  
smallest number of barrel cylinders likely to  
45 operate simultaneously under high-pressure  
condition, so that the distribution plate is  
urged by the high pressure fluid against  
the arcuate face of said case.

In fact, since machines of this type comprise  
50 as a rule an odd number of pistons, mostly  
seven, there is alternatively a number differing  
by one unit of pistons operating simultaneously  
under high pressure (alternatively 3 or 4 in  
the case of a seven-piston machine). Although  
55 it would be desirable that the contact pressure  
exerted by the distribution plate against the  
arcuate face of the case be as low as possible,  
this contact pressure must be calculated as a  
function of the minimum number of pistons  
60 likely to operate simultaneously under  
pressure, so that any clearances be constantly  
taken up in the same direction. This means  
that the contact pressure varies cyclically  
by reason of at least the thrust of a piston in a  
65 cylinder under pressure, which is excessive  
from the point of view of mechanical  
strength and wear and tear. Moreover, the  
limitation thus imposed to the surface area  
of said elongated orifices leads to limit  
70 likewise the corresponding cross-sectional  
passage areas for the fluid, thus causing a  
loss of efficiency due to a loss of pressure,  
which is particularly detrimental at high  
operation speeds.

If the cross-sectional area of the  
75 elongated orifices of the distribution plate  
exceeds the surface area of the plurality  
of cylinders likely to operate simultaneously  
under pressure, this is practically inconsistent  
80

with the conventional structure of pumps of this type.

It is the primary object of the present invention to provide a hydraulic machine of the axial piston type which is capable of meeting satisfactorily this last-mentioned requirement by eliminating the above-described inconveniences.

For this purpose, in an axial-piston hydraulic machine wherein the pistons are disposed in parallel relationship within a rotary barrel comprising the piston receiving cylinders communicating with orifices opening on a circular path concentric to the barrel axis and registering with a distribution plate in sliding contact with a case comprising corresponding high-pressure and low-pressure fluid passage ports, said barrel being rotatably mounted said distribution plate, a first face of said distribution plate which is opposite the barrel-engaging face being arcuate and adapted to co-act with a first corresponding arcuate face of the case of the machine which comprises high-pressure and low-pressure fluid passage orifices, said last-mentioned orifices registering with elongated orifices formed in said distribution plate of which the cross-sectional surface is greater than the surface of the plurality of cylinders likely to operate simultaneously under pressure, this invention being characterised in that said distribution plate comprises an arcuate face directed towards said barrel but bearing against a second arcuate face of said case.

Preferably, hydrostatic bearings are formed between the aforesaid arcuate face directed towards said barrel and said second arcuate face of said case, said bearings being advantageously of the self-regulating or self-adjusting type.

Other features and advantages of this invention will appear as the following description proceeds with reference to the accompanying drawing illustrating a typical form of embodiment of a hydraulic machine constructed according to the teachings of this invention. In the drawing:

Figure 1 is an axial section of the machine, taken along the line I-I of Figure 2;

Figure 2 is a section taken along the line II-II of Figure 1;

Figure 3 is a view taken in the direction of the arrow III of Figure 4, showing the distribution plate;

Figure 4 is a side elevational view of the distribution plate, as seen in the direction of the arrow IV of Figure 3;

Figure 5 is a section taken along the line V-V of Figure 4, and

Figure 6 is a view similar to Figure 5 but showing a modified form of embodiment.

To facilitate the description, it will be assumed that the machine illustrated in the drawing is a pump, but it will readily occur to

those conversant with the art that this machine may also be operated as a motor.

The pump illustrated comprises a case having a central body 1 closed at one end by a plate or flange 2; a pump driving shaft extends through the center of this plate 2; the opposite end of said body 1 is closed by a cover 4 comprising a (low pressure) inlet port 5 and a (high pressure) outlet port 6 for the working fluid. This shaft 3 is adapted rotatably to drive through splines 7 an impeller plate 8 mounted by means of a roller bearing 9 in said body 1. The impeller plate 8 is formed with part-spherical recesses engaged by the corresponding spherical "big-ends" of connection rods 10 having their "small ends" coupled to corresponding pistons 11 slidably mounted in parallel axial cylinders 12 consisting of bores formed in a barrel 13, these cylinders being disposed at spaced intervals along the generatrices of a cylinder and being for example seven in number.

Another function of shaft 3 is to rotatably drive the barrel 13 through a homokinetic transmission comprising a connecting-rod 14 provided with cross-pins 14a, 14b engaging internal splines of shaft 3 and barrel 13 and coupled through ball-and-socket means therewith. One of the crosspins mounting said connecting-rod engages a bearing member 15 engaging in turn a spring 16 housed within the shaft 3 in order to compensate the variations occurring in the position of said connecting-rod when the barrel assumes a different inclination in relation to the impeller plate 8, as will be explained presently.

The barrel 13 is rotatably mounted by means of a bearing 17 on a stub shaft extension 18 of a fluid distribution plate 19 interposed between said barrel 13 and the case cover 4. This distribution plate 19 has a face 20 registering with the adjacent face of the barrel and having formed therein a low-pressure arcuate port 21 and a high-pressure arcuate port 22 for the pumped fluid, said ports being interposed in the path of the cylinder bottom orifices 23. The distribution plate 19 further comprises a face 24 opposite said face 20 which is also arcuate and co-acts with an internal and similar arcuate face 25 of cover 4, these arcuate faces consisting of part-cylindrical surfaces centered at 26, i.e. centrally of the impeller plate 8 and in the plane comprising the axes of the ball-and-socket joints interconnecting the connecting-rods 10 and the impeller plate 8, whereby the distribution plate 19 can be moved angularly about the center axis 26 for varying as required the inclination of said barrel 13 in the case, and consequently the cubic capacity of the machine. In this example, this variation is obtained by means of an arm 27 fulcrumed to a pivot pin 28 carried by plate

- 19 (see Figure 1). This plate 19 is further-  
more guided laterally in the case body 1 by  
having its side faces in sliding engagement  
with lateral guideways 29, but obviously  
5 this guiding action may also be obtained  
between the plate 19 and the cover 4, for  
example by means of a key and groove  
arrangement. The top face 24 of distribution  
plate 19 has a pair of elongated orifices 30,  
10 31 formed therein which communicate via  
internal passages 32, 33 formed in said  
plate 19 with the inlet and outlet ports 21, 22,  
respectively, for the pumped fluid. These  
elongated orifices 30, 31 are adapted to  
15 cover the inlet and outlet orifices 5 and 6,  
respectively, terminating at the arcuate face  
25 of said cover 4, irrespective of the  
inclination likely to be assumed by the plate  
19 and barrel 13 together. Adequate seals 34  
20 surround the elongated orifices 30, 31 to  
prevent any leakage therearound; if  
desired, the seals disclosed in the Applicants'  
British Patent No. 1.353.642 may be used for  
this purpose.
- 25 The cross-sectional area of at least one  
high-pressure elongated orifice 31, and in this  
example also that of the elongated orifice 30,  
at least in the case of a reversible machine,  
is selected to be greater than the surface area  
30 of all the cylinders likely to operate  
simultaneously under high-pressure condition,  
so that the thrust exerted by the pumped or  
forced fluid will tend to constantly urge the  
distribution plate against the barrel, i.e.  
35 with a force in excess to that resulting from  
the action exerted by the fluid pressure in the  
cylinders, even if at the time four out of the  
seven cylinders are operating under high  
pressure condition. The difference between the  
40 high-pressure fluid thrust exerted through the  
corresponding elongated orifice against the  
distribution plate, on the one hand, and the  
opposite thrust of the high-pressure fluid  
which is exerted within the corresponding  
45 cylinders, on the other hand, will thus be  
predominant in the direction from the  
distribution plate to the barrel, and is  
compensated in this case by means of a  
hydrostatic bearing provided between the  
50 distribution plate and the case, along  
registering arcuate faces 35, 36, homologues of  
the aforesaid arcuate faces 24, 25, said  
arcuate faces 35, 36 also consisting  
thereof of cylindrical surfaces centered to  
55 the axis 26. These bearings comprise  
elongated cavities, in this example four in  
number, namely two on either side of the  
plate, these cavities being designated by the  
reference numerals 37, 38, 39, 40 and formed  
60 in the arcuate surfaces 35 of the plate from  
which these cavities are supplied with high-  
pressure fluid.
- Figure 5 illustrates a typical form of  
embodiment of said cavities corresponding to a  
65 pump or motor construction wherein the  
port 22 and the relevant passage 33 are in all  
cases high-pressure fluid passages, this passage  
33 being in this example connected via  
internal bores to the four cavities 37-40  
70 These internal conduits comprise a pair of  
blind secant bores 41-42 stopped after  
drilling them in said plate 19, one bore 41  
passing through the aforesaid passage 33; four  
stopped bores 43, 44, 45, 46 opening into the  
75 other bore 42, and four small bores 47, 48,  
49 and 50 connecting said bores 43-46  
to cavities 37, 38, 39 and 40. Preferably,  
these bearings are of the self-regulating or  
self-adjusting type in a manner known per se,  
by supplying said cavities by means of narrow  
80 orifices adapted to cause a loss of pressure  
and consisting in the example of helical  
grooves formed on the outer periphery of  
cylindrical plugs 51 inserted into the bores  
43 to 46, and also by giving to said cavities  
relatively large dimensions whereby the  
variations in their leakages entail substantial  
variations in the pressure prevailing in each  
cavity, whereby these bearing will constantly  
90 adapt themselves to the distribution plate  
thrust to be compensated. In fact, it may be  
reminded that this thrust to be compensated  
varies both in amplitude and in position  
as to its resultant, considering the fact that  
the pistons operating simultaneously under  
95 high-pressure condition are alternatively  
three or four in number in the machine con-  
templated herein.
- Of course, hydrostatic bearings having  
cavities of smaller cross-sectional area may be  
100 used, and these cavities may be supplied  
directly with fluid under pressure; in this  
case, the thrust variations are absorbed  
mechanically. Alternatively, any other bearing  
structure, even of mechanical construction,  
105 such as ball-bearings, may be used, provided  
that their size be consistent with the thrust  
to be coped with, which may be as high as  
implied notably by the choice permitted by  
the present invention of cross-sectional  
110 fluid passage areas directed to reduce losses  
of pressure and improve the efficiency of the  
machine.
- Figure 6 illustrates as an alternative a  
modified form of embodiment of the  
115 cavities of the above-described hydrostatic  
bearings, which corresponds to the case of a  
pump (or motor) wherein the functions of  
ports 21, 22 and of the corresponding passages  
32, 33 may be inverted, said last-mentioned  
120 passages 32, 33 being connected in this case  
to the bore 42 via a bore 41a in which a  
ball-type selector valve 52 is interposed, the ball  
of this valve closing automatically, under the  
influence of the fluid under pressure issuing  
125 from the high-pressure fluid passage 32 or 33,  
the communication between said bore 42 and  
the other low-pressure passage 33 or 32.
- Although a specific form of embodiment  
of this invention has been described herein-  
130

above and illustrated in the accompanying drawing, it will readily occur to those skilled in the art that various modifications and changes may be brought thereto without departing from the scope of the invention as set forth in the appended claims.

WHAT WE CLAIM IS:—

1. A hydraulic machine having axial pistons disposed in a rotary barrel comprising cylinder bores for slidably receiving said pistons, said bores communicating with orifices opening along a circular path concentric with the axis of rotation of said barrel, and registering with a distribution plate in constant sliding contact with a case, said distribution plate comprising corresponding high-pressure and low-pressure fluid passage ports, said barrel being rotatably mounted in relation to said distribution plate, a first face of said distribution plate opposite to the barrel-engaging face being arcuate and co-acting with a first arcuate face of corresponding curvature formed in the machine case, said first arcuate face of the machine case comprising high-pressure and low-pressure passage orifices registering with elongated orifices formed in said distribution plate, the surface area of said elongated orifices exceeding the total surface area of the plurality of cylinders likely to operate simultaneously

under high-pressure condition, this machine being characterised in that said distribution plate further comprises an arcuate face directed towards said barrel which bears against a second arcuate face of said case.

2. Axial-piston hydraulic machine as disclosed in claim 1, characterised in that hydrostatic bearings are provided between said arcuate face directed towards said barrel and said second arcuate face of said case.

3. Axial-piston hydraulic machine as disclosed in claim 2, characterised in that said hydrostatic bearings consists on said distribution plate of cavities supplied with hydraulic fluid under high pressure from an internal passage of said distribution plate.

4. Axial-piston hydraulic machine as disclosed in claim 2 or 3, characterised in that said hydrostatic bearings are supplied separately via narrow passages adapted to create pressure losses.

5. Axial-piston hydraulic machine substantially as described herein with reference to the accompanying drawings.

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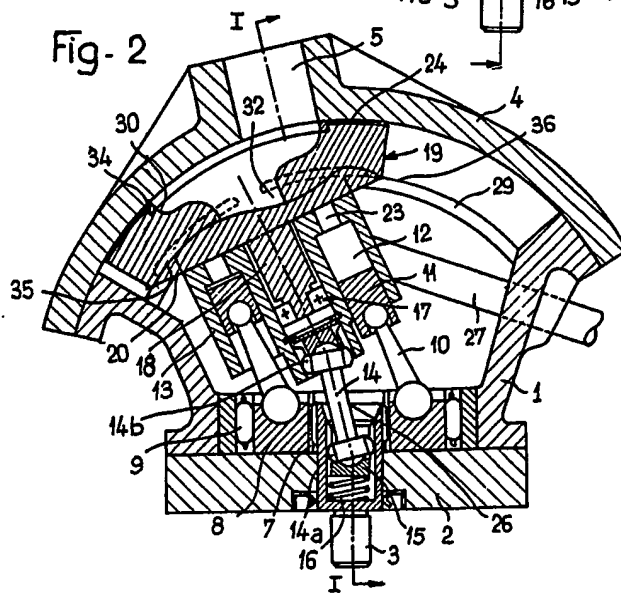
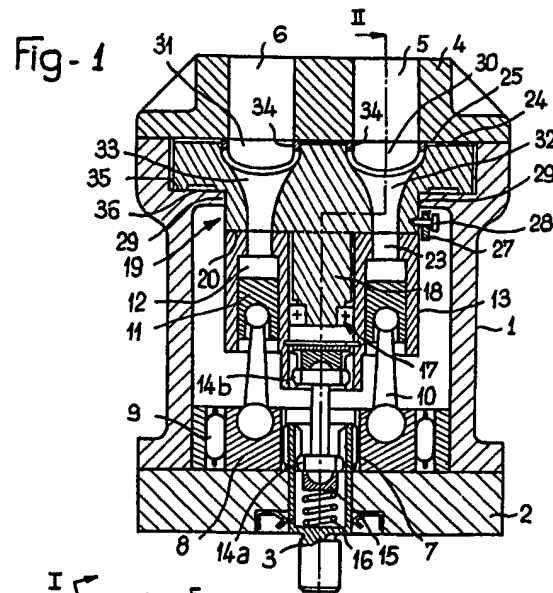
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## COMPLETE SPECIFICATION

**2 SHEETS**

**This drawing is a reproduction of  
the Original on a reduced scale**

Sheet 1



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## COMPLETE SPECIFICATION

2 SHEETS

*This drawing is a reproduction of  
the Original on a reduced scale*

Sheet 2

Fig- 3

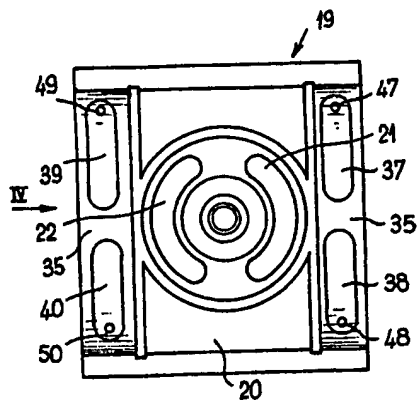


Fig- 4

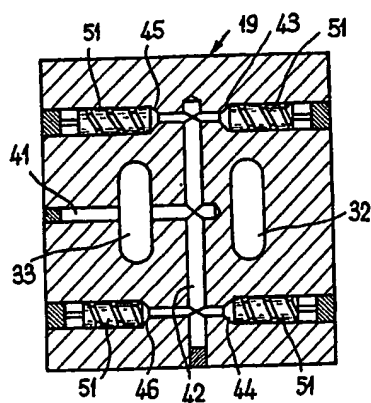
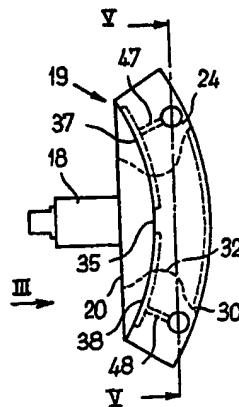


Fig- 5

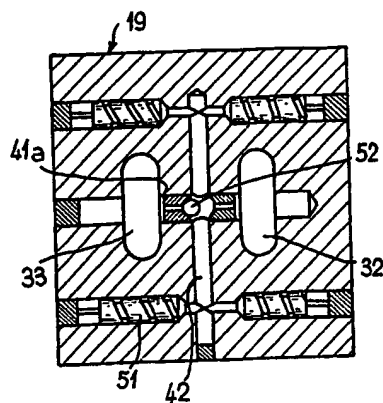


Fig- 6